POPULATION DYNAMICS OF AN ISOLATED POPULATION OF THE HARVESTMAN *ILHAIA CUSPIDATA* (OPILIONES, GONYLEPTIDAE), IN ARAUCARIA FOREST (CURITIBA, PARANÁ, BRAZIL)

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ABSTRACT. The harvestman *Ilhaia cuspidata* was studied in Curitiba, state of Paraná, Brazil. The site studied is a 30,000 m² forest remnant of *Araucaria* forest surrounded by houses. Harvestmen were sampled 21 times over 14 months (June 1997–August 1998); at intervals of 21–30 days. The population size was estimated by Fisher-Ford and Jolly methods, and did not vary considerably from autumn (June) to spring (November 1997). However, it increased rapidly (300 %) during late spring and summer (December–March). The lowest population size estimated was 1,429 adults/subadults, during the winter (June 1997) and, the highest was 14,445 during the autumn (April 1998). The recapture rates ranged from 16%–41%. The sex ratio observed in all sampling periods was 1:1. The density varied from 0.05 (winter) to 0.47 adult + subadults/m² (autumn). The extremely different abundances observed between seasons could have been influenced by temperature. The immatures were observed all year, suggesting a continuous reproduction, but they were much more abundant during spring and summer. Ecological aspects including aggregation, individual movement and life span were also discussed.

Keywords: *Araucaria* forest, *Ilhaia cuspidata*, Opiliones, Population ecology

Harvestmen are normally solitary, nocturnal, omnivores, vagile and photophobic (Coddington et al. 1990; Savory 1938). They are commonly found in humid forests, under fallen trunks, in leaf litter, mosses and inside caves (Edgar 1990). Members of this order are very common in Neotropical forests, where their diversity can be very high, in the Atlantic Rain Forest of Brazil, more than one harvestmen can be found per square meter (Pinto-da-Rocha pers. obs.). In temperate zones harvestmen biomass sometimes can exceed that of spiders and they may be important controllers of insect populations (Hillyard & Sankey 1989).

Data on population biology and the natural history of Opiliones in South America are very scarce (see Gnaspini 1996; and Pinto-da-Rocha 1999 for references). Specific studies related to the ecology and population biology of Neotropical harvestmen have been conducted with *Goniosoma spelaeum* (Mello-Leitão 1933) (Gonyleptidae, Goniosomatinae) in caves of the Ribeira valley, São Paulo, Brazil (Gnaspini 1996), *Pachylospeleus strinatii* Silhavý 1974 in the "Gruta das Areias de Cima", São Paulo, Brazil (Pinto-da-Rocha 1996a), *Daguerreia inermis* Soares & Soares 1947 in the "Gruta da Lancinha", Paraná, Brazil (Pinto-da-Rocha 1996b), and *Pachyloidellus goliath* Acosta 1993 in "Pampa de Achala", Córdoba, Argentina (Acosta et al. 1995).

In southeastern Brazil, the composition of harvestmen fauna of the Atlantic Rain Forest is different in each mountain chain and more than 50 species can be found in each area of endemism (Pinto-da-Rocha 1999). Most species are endemic, occupying small areas, normally one mountain chain or some caves (Pinto-da-Rocha 1999). The cavernicolous harvestmen do not vary in abundance through the year, and their populations seem to be more stable than epigean populations (Gnas-

pini 1996; Pinto-da-Rocha 1996a; 1996b), probably because epigean climates are more variable than inside caves. Thus, we expect that epigean harvestmen populations will vary in abundance through the year.

The epigean species *Ilhaia cuspidata* Roewer 1913 has a wide distribution, occurring in southern to southeastern Brazil from the state of Rio de Janeiro to Paraná. It inhabits leaf litter of subtropical humid forests and synantropic environments, such as second growth and forest fragments inside cities. In this study we examinate the population dynamics and intra and interspecfic interactions of this harvestmen species in an urban site, intending to understand possible seasonal variations in abundance and other biological aspects.

METHODS

Study site (Fig. 1).—This study was carried out in an Araucaria forest fragment, located in the "Museu de História Natural do Capão da Imbuia" east of Curitiba county, Brazil (25′25″48°S, 49′16″15°W). This forest fragment comprises 30,000 m² that was isolated in the last 50–70 years and today is surrounded by houses, prior the park foundation. The Araucaria forests in south Brazil are characterized by trees averaging 25–30 m high, with great biomass of large Gymnospermae *Araucaria angustifolia* (Bertol. 1898.) Kuntze. Open understories are dominated by shrubs and vines, and in secondary forests, the case of this study, the ground is mainly covered by leaves and fallen trees, where harvestmen can live. Subtropical Humid Mesotermic characterizes the climate of the region, with a warm season and a cold season with frequent frosts (May–September). The mean temperature in the warm season is below 22 °C and in the coldest months are below 12 °C. The annual mean is 17 °C. Rainfall is between 1300 and 1500 mm per year (105–190 mm each month from September–March and 78–102 mm from April–August) and relative humidity averages 85% (Mack 1981) (Fig. 2). The meteorological data (Fig. 2) used in this study were obtained from the "Estação Meteorológica do Centro Politécnico" (located 5 km from the study site) supplied by the "Sistema Meteorológico do Paraná (SIMEPAR)".

Capture-recapture.—Individual harvestmen were collected from June 1997 to August of 1998 by one person, during daylight, with intervals of 21–30 days between each one of the 21 samples. The time spent in the field taking samples varied from 5–16 h, depending on the total number of captured animals. The study site was arbitrarily divided into 23 sampling points of strips of 100 m² (Fig. 1). At each sample point all harvestmen were carefully collected (under fallen trunks, boards, bricks, etc.) with forceps and a flashlight for searching in crevices. All adults and last nymphal stages (i.e., harvestmen without arolium, see Munõz-Cuevas 1971) encountered were captured. The immature stages of *I. cuspidata* Roewer 1913 and other harvestmen species observed were counted, but not captured or marked. After capture, the harvestmen (adults and last nymphal stages) were sexed (differentiated mainly by heavy armature of male leg IV, weak on females), counted and marked with acrylic or plastic ink on the back region of the dorsal scute or on the femora of the fourth leg in specific combinations of colors for each sample date. This ink did not harm the individuals and after several recaptures the marks were still easily recognizable (see Appendix 1). The marked individuals were released at the same place where they were collected. Voucher specimens were deposited in the Museu de Zoologia da Universidade de São Paulo and Museu de História Natural "Capão da Imbuia".

Shelter preferences.—The 23 sample points were characterized on the basis of the quantity of possible shelters present in each sample site (100 m²) that could be influencing the local abundance of harvestmen. The shelters were classified in 4 categories for subsequent statistical analysis: trunks, stones, bricks and trash (objects of inorganic origin, plastic objects). We compared separately the number of adult harvestmen observed per sample point, in habitats with high (H), medium (M) and low (L) concentration of different shelters by Kruskal-Wallis and Dunn's Tests.

Behavioral observations.—Prior to our population study we collected harvestmen on three dates (21 March, 11 April and 5 May 1997). At these times captured individuals were individually marked with a small drop of acrylic ink. These data were not considered in the estimates of population size, but they were used for observations of individual movements. During each sample period we re-

Figure 1.—Map of the study site, Curitiba, Brazil.

corded the number and sex of aggregated individuals. We considered as "aggregated" harvestmen that had legs in contact with one or more others harvestmen. We established five categories of aggregations: (a) males only, (b) females only, (c) both males and females, (d) males, females and immatures and (e) multi-species aggregations, with individuals of *I. cuspidata* and other harvestmen species. We analyzed differences between numbers of individuals in aggregates by seasons. We made two night observations in the study site (on 20 March and 13 July 1998). We counted the active individuals observed in a 100 m transect (width 5 m), in periods of 15 minutes, from 1700 h–2000 h. Behavioral and foraging observations were made in a hexagonal terrarium of glass (50 x 40 cm) with approximately 2 cm of soil, three shelters and two plastic receptacles with water. This terrarium housed 13 individuals of *Ilhaia cuspidata*, one female of *Discocyrtus* sp.2, one male of the spider *Polybetes pitagoricus* (Holmberg 1875) (Araneae, Sparassidae), one female of the spider *Ctenus* sp. (Araneae,

Ctenidae) and two diplopods. Also included were crickets, cockroaches, isopods and slugs.

Statistical methods.—The population size of *I. cuspidata* was estimated by Fisher-Ford and Jolly algorithms (Begon 1979). Both methods require several phases of marks and recaptures. In the Fisher-Ford method, the population size is estimated with the assumptions that the relationship between marked and total individuals found during the sampling period is the same for the whole population and that survival rate is constant and independent of age. In this study, only the adults and last nymphal stage were sampled. Jollys method considers only the most recent recaptures and the oldest are ignored (Begon 1979). This method calculates a survival rate for each sample (Begon 1979). Although the marks on the subadult stage could be lost, these individuals were also included in the population estimates because it is difficult to separate them from the adults in the field, and because this stage can span more than 9 months in some harvestmen species (Gnaspini 1996). The data obtained using each method were
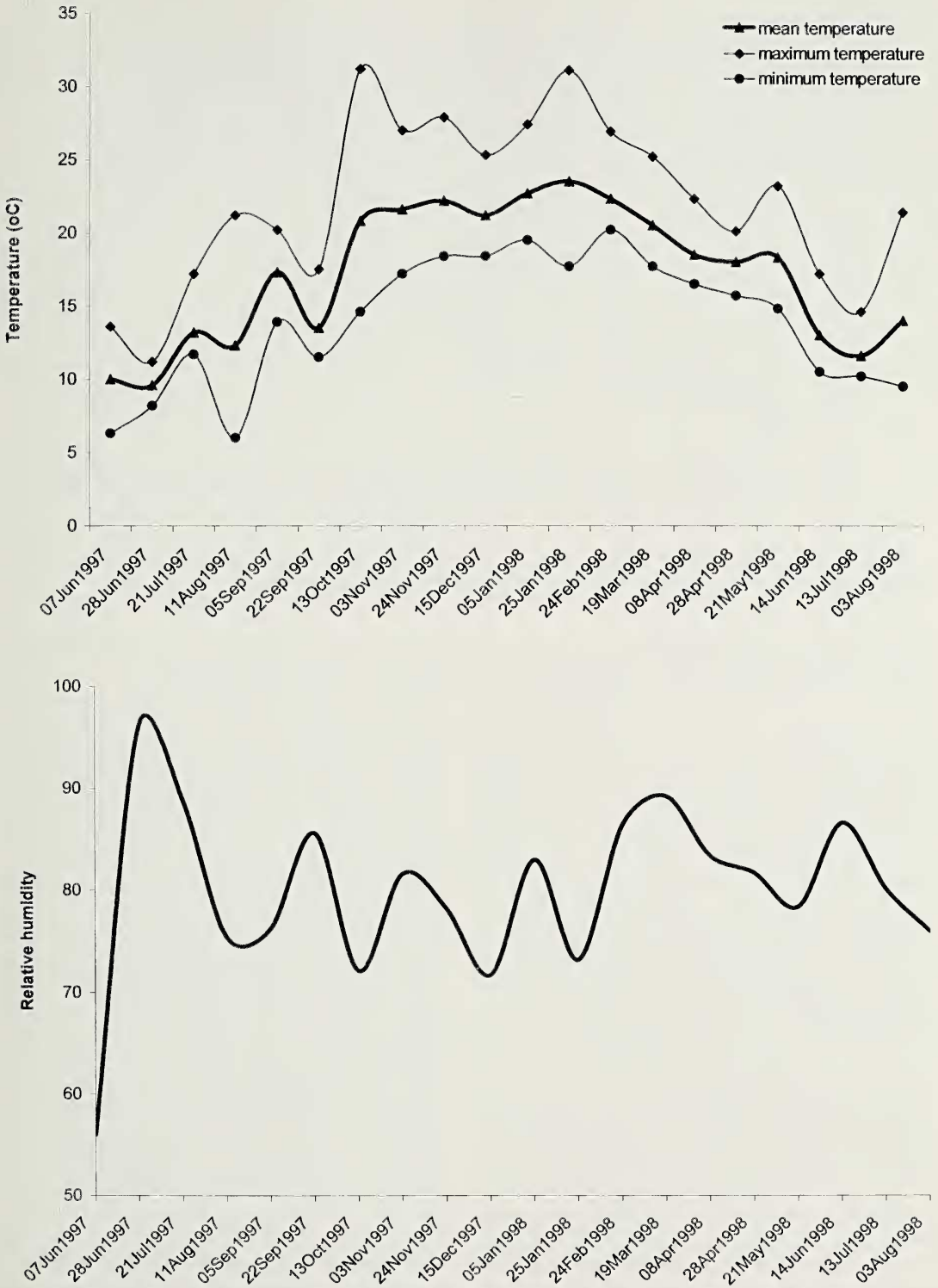
Figure 2.—Mean, maximum and minimum temperature (above) and relative humidity (below) in study site. Autumn began on 20 March, winter on 21 June, spring on 23 September and summer on 21 December.
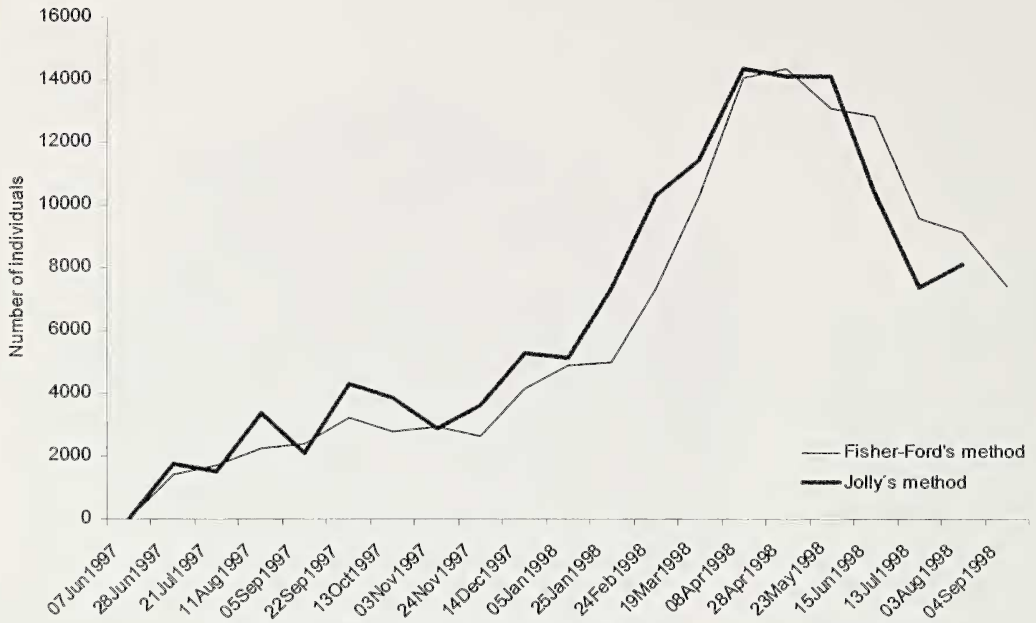
Figure 3.—Estimates of population size of adults and subadults of *Ilhaia cuspidata* by Jolly and Fisher Ford's capture-recapture methods in an Araucaria forest fragment in Brazil.

compared with a Mann-Whitney U test. Comparisons of population size between seasons were made with ANOVA and Tukey's q test. The density of harvestmen at the study site was determined by dividing the population estimate divided by the total area of the fragment (30000 m^2). We used chi-square to test whether the sex ratio deviated from 1:1 and the association between juveniles and adults observed in the four seasons sampled. We used Kruskal-Wallis (KW) and Dunn's Q to test for possible differences in harvestmen abundance in habitats with distinct concentrations of shelters, seasonal variations in abundance of other species of harvestmen, and seasonal differences in abundance of aggregations.

RESULTS

Population dynamics.—The estimated population sizes of *Ilhaia cuspidata* were similar for both population estimation methods, Jolly and Fisher-Ford (Mann-Witney U = 178.00 P = 0.624) (Fig. 3, Appendix 1). The Fisher-Ford method presented less variation when compared with the Jolly estimate, probably due to the importance of all capture and recapture data points in the population size estimates. On the other hand, the Jolly method analyzed data more consistently for the day of captures/recaptures (Begon 1979). Herein,

these data will be discussed mainly with the Fisher-Ford estimation method.

The population estimates ranged from a low of 1,429 individuals in the second sample (winter, 7 June, 1997), to a maximum of 14,445 in the sixteenth sample (autumn, 28 April, 1998). A slight and progressive population growth was observed from June to November of 1997, when the estimated values oscillated between 1,429 and 2,661 individuals (Fig. 4). There were significant seasonal differences in the mean population size of *Ilhaia cuspidata* showed a significant difference in winter and autumn, spring and autumn, and summer and autumn, (ANOVA P < 0.0001, Tukey q = 16.3 for winter vs autumn, 14.8 for spring vs autumn, 11.34 for summer vs autumn, P < 0.001). Population size remained low from the end of the winter (June) to the spring (November) and increased quickly in the following four months, during the spring and the summer (increasing 300%). In summer (January 1998) the population increased very rapidly, and in the period of four months, increased from 2,661 to 14,445 adult/subadult estimated individuals. The highest estimate occurred on the sixteenth sample date (28 April 1998), when 1,738 individuals were captured of which 1,227 were marked (Fig. 3,

Table 1.—Total number of males (M) and females (F) of harvestmen species observed on each sample date at the study site. *D.1. Discocyrtus* sp*1*, *D.2. Discocyrtus* sp2, *Tr. Tricommatidae*, *G.* sp. *Geraecormobius* sp., *I.c.* = *Ilhaia cuspidata* marked, jv. = juveniles, † = dead observed.

Sample date	*D.1.* M	*D.1.* F	*D.2.* M	*D.2.* F	*Tr.* M + F	*G.* sp. M	*G.* sp. F	*I.c.* M	*I.c.* F	*I.c.* jv.	*I.c.*†
07 June 1997	1	1	0	0	0	1	0	157	135	8	0
28 June	1	1	0	0	1	0	0	113	73	1	0
21 July	1	6	0	0	3	0	0	107	107	5	0
11 August	0	2	1	0	4	1	1	131	131	2	0
05 September	3	3	0	0	8	0	0	112	113	5	5
22 September	4	6	1	1	8	2	0	127	159	0	1
13 October	5	8	1	1	3	1	2	92	95	50	1
03 November	8	13	1	1	4	2	2	78	134	144	1
24 November	6	9	0	0	5	0	0	104	96	334	2
14 December	4	5	1	1	6	1	0	149	136	226	1
05 January 1998	8	12	0	3	7	2	0	274	224	154	1
25 January	16	11	0	0	4	4	5	300	267	141	3
24 February	23	22	0	2	18	2	1	482	497	87	1
19 March	13	18	1	2	6	1	1	539	624	94	8
08 April	18	16	1	2	7	1	2	696	763	76	17
28 April	5	9	3	2	11	0	0	567	660	38	20
23 May	6	7	0	0	5	2	1	390	445	30	22
15 June	3	10	1	2	8	0	1	324	374	23	34
13 July	3	4	1	0	7	3	2	184	206	25	37
03 August	4	8	0	0	13	2	2	151	159	24	34
04 September	4	7	1	0	8	1	0	92	128	13	72
Total	136	178	13	17	136	26	20	5169	5526	1480	259

Appendix 1). The rates of recapture of marked individuals varied from 16% (28 June 1997) to 41% (24 November 1997) of the total captured in daylight.

The density of *Ilhaia cuspidata* in the study site varied between 0.05 adults/m² (in the winter) to 0.47 adults/m² (in the summer). The adult sex ratio was 1:1 for the entire study period (X^2 = 33.82 df = 20 P < 0.027). However, when the seasons were analyzed separately, only in spring the was sex ratio 1:1 (X^2 = 9.37 df = 3 P < 0.024), in other seasons these data showed alternating sex predominance (winter I: males > females X^2 = 5.13, df = 4, P < 0.27, summer: males > females X^2 = 6.99 df = 4 P < 0.14, autumn: males<females X^2= 9.28, df = 4, P < 0.054 and winter II: males < females X^2 = 3.049, df = 1, P < 0.08).

Immature individuals were observed in almost every sampling period. We counted 335 immatures during November 1997 (Table 1, Fig. 3), resulting in a maximum relative density of 0.01 immature/m². We observed significant association between the total number of juveniles and adults observed in each sea-

son (X^2 = 1566.2, 4 df, P < 0.0001), abundance of adults and juveniles are associated and there is probably a reproductive period. The higher number of juveniles observed in spring and summer was associated with the higher number of adults observed in summer and autumn (Table 1).

The differences in harvestman abundance in habitats with high (H), medium (M) and low (L) concentration of trunks and bricks is extremely significant (Trunks KW = 22.78, Dunn $Q_{L,H}$ = −22.4/$Q_{M,H}$ = −35.57 P < 0.001; Bricks KW = 25.7, $Q_{L,H}$ = −32.12 / $Q_{L.M.}$ = −22.51 P < 0.001). These data show that, where there is higher concentration of trunks and/or bricks, there is a corresponding higher concentration of harvestmen. Stone and trash concentrations seem to be less important for concentrations of *Ilhaia cuspidata* (Stones KW = 10.07, Dunn $Q_{L,H}$ = −29,2 P < 0.05; Trash KW = 12.88, Dunn $Q_{L,H}$ = −31.00/$Q_{L.M.}$ = −30.51 P < 0.05).

Aggregations.—We observed 522 aggregations of *Ilhaia cuspidata*, 6.5% with males only (KS = 0.24, mean per sample day X = 2; SD = 2.15; n = 21); 9.2% females only
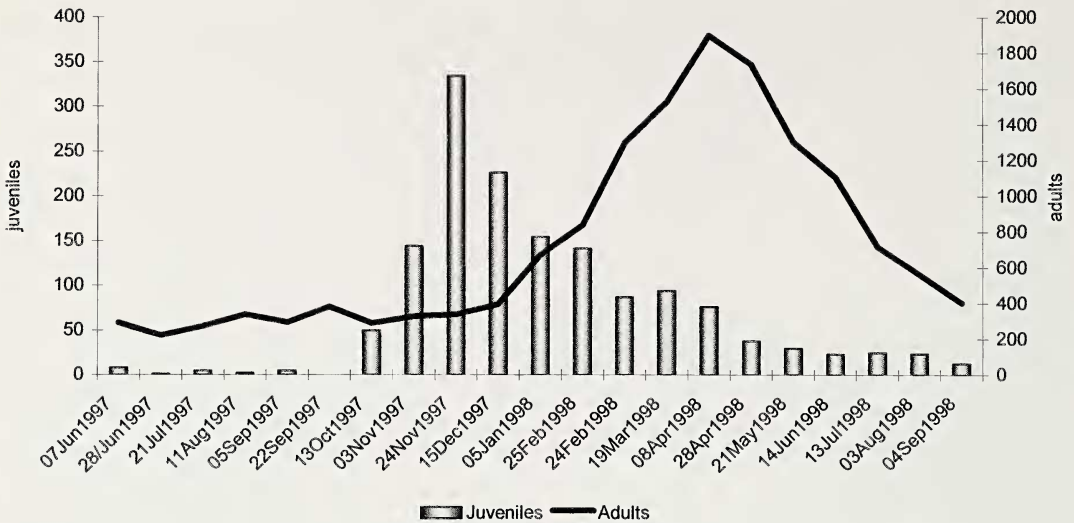
Figure 4.—Number of immatures and adults of *Ilhaia cuspidata* in an Araucaria forest fragment in Brazil.

($KS = 0.17$; X $= 2.7$; SD$= 2.13$; $n = 21$); 56.9% males and females ($KS = 0.18$, X$= 17.5$; SD$= 12.7$; $n = 21$); 16.5% males, females and immatures ($KS = 0.31$ $P = 0.02$ NS); and 10.9% were multi-species aggregations ($KS = 0.19$, X$= 3.3$; SD$= 2.66$; $n = 21$) (Table 2).

Aggregations with fewer than five individuals were the most common kind of aggregations, but the number of these aggregations is constant through the year (KW $= 10.176$, $P = 0.03$, Dun's NS, $P > 0.05$). Aggregations that contained from 6–9 individuals show a significant increase in summer (Su) and autumn (Au) when compared with spring (Sp) (KW $= 16.77$, Dunn $Q_{SpSu} = -14.87$ $P < 0.01$, $Q_{SpAu} = -13.37$, $P < 0.05$). We also observed a significant increase in the number of aggregations with more those 10 individuals when comparing spring and autumn (KW $= 15.00 Q_{SpAu} = -15.00$, $P < 0.05$). The analysis of all aggregations together shows similar results (KW $= 14.72$, $Q_{SpSu} = -13.62$, $Q_{SpAu} = -14.12$, $P < 0.05$). Thus, aggregations larger than six individuals were more abundant in summer and autumn.

Individual movements and life span.— During the three previous collections, taken before the sampling period, 238 individuals of *I. cuspidata* were individually marked (numbered). We recaptured 50 of those specimens during the 335 sample days. About 50% of these individuals were found in the same place

that they were marked, 46% were found close to these sites (between 10 and 20 m) and the remained 4% were found approximately within 60 meters from the point that they were captured. These data show very low vagility of this opilionid species. The number of harvestmen recaptured decreased constantly across the study period and the last recaptures were made just one year after they had been marked, in the 15th sampling (April 1998). Longevity of adults is more than 455 days.

Natural history.—Field observations showed that *I. cuspidata* is practically motionless during the day, taking shelter in the interior or under fallen trunks, stones and pieces of wood. Individuals were also observed taking shelter under plastic objects and other trash. During the two nocturnal samples, one in the warm season (March 1998), and the other in the cold season (June 1998), we observed that the harvestmen began activity early in the night, about 15 minutes after sunset. An increase in the number of active individuals was observed 30 minutes after sunset, when it was almost dark (light intensity was 02 lux). On 15 June 1998, just after sunset, from 1730–1745 h, no active harvestmen were observed. The observations from 1750–1905 h revealed an incremental increase in harvestmen activity. From 1750–1805 h, all the individuals (16) of *I. cuspidata* seen were active; 18 were observed from 1810–1825 h; 38 from 1830–1845; and 44 from 1850–1905

Table 2.—Number of aggregations of *Ilhaia cuspidata* composed of only males (M); only females (F); males, females and juveniles (M + F + jv.); and interspecific aggregations (intrsp.).

Date	M	F	M + F	M + F + jv.	Intrsp.	Total
07 June 1997	4	6	19	1	1	31
28 June	2	1	9	0	3	15
21 July	2	3	15	0	1	21
11 August	1	0	7	1	1	10
05 September	3	4	17	0	4	28
22 September	0	3	7	0	0	10
13 October	0	1	9	2	4	16
03 November	0	0	7	1	2	10
24 November	0	0	3	1	1	5
15 December	2	1	6	20	2	31
05 January 1998	2	3	12	10	5	32
25 January	2	3	16	12	10	43
24 February 1998	9	5	36	12	8	70
19 March 1998	3	7	46	10	5	71
08 April 1998	2	5	37	12	3	59
28 April 1998	1	2	31	3	5	42
21 May 1998	1	3	20	2	2	28
Total	34	47	297	87	57	522
%	6.50	9.20	56.90	16.50	10.90	100.00

h. Activity during daylight was never observed outside the shelters.

In the field, individuals of *I. cuspidata* were observed feeding on small adult lepidopterans, bird and rodental feces (probably Cricetidae). In captivity, individuals accepted several kinds of vegetables and fruits (e.g. papaya, banana, peach, beet, and carrot).

We observed animals coexisting with *I. cuspidata*, such as toads, worms (Oligochaeta and Hirudinea), crickets, spiders, pulmonate mollusks, pseudoscorpions, coleopterans (Passalidae, Staphylinidae) and other insects. Frequently, we observed the presence of small crickets (Phalangopsidae) and a species of pulmonate mollusk near *I. cuspidata*.

The spider *Scytodes* sp. (Araneae, Scytodidae), was observed preying on a young *I. cuspidata*, and feeding on the remains of an adult exoskeleton. One dead individual of *I. cuspidata* was found in the web of a Theridiidae spider. Besides these predators, it is possible that toads (*Bufo* sp.), ants (*Pachycondyla* sp. and *Odontomachus* sp.) and some spiders (e.g. *Ctenus* sp.) in the study site could prey on harvestmen.

Egg-batches of *I. cuspidata* were rarely found (even previous to the peak of young recruitment), probably due to the difficulty of locating them among the leaf litter. The eggs measured approximately 1mm in diameter, were white in color, opaque and sticky. They were laid under fallen leaves in clusters of up to 20 and did not receive any additional care by the female. An egg batch containing 8 eggs was collected in the field and maintained in a plastic box with leaves and wet cotton in the bottom. After 3 weeks, four nymphs hatched.

Other harvestmen species.—Other harvestmen species observed coexisting with *Ilhaia cuspidata* were two species of *Discocyrtus* (Gonyleptidae, Pachylinae, one black, sp. 1 and another red, sp. 2), one species of *Geraecormobius* sp. (Gonyleptidae, Gonyleptinae), and one species of an unidentified genus of Tricommatidae. We observed significantly higher abundance of *Discocyrtus* sp. 1 in summer (Su) and autumn (Au) when compared with the first winter studied (Wi) (KW = 13.93, $P = 0.007$; $Q_{WiSu} = -12.4$, $Q_{WiAu} = -13.2$, $P < 0.05$). We also observed an increase in Tricommatidae (24 February 1998), *Geraecormobius* sp. (25 January 1998) and *Discocyrtus* sp. 2 (28 April 1998) (Fig. 5 & Table 1). These species seem to have a population increase in the same season as *Ilhaia cuspidata* and *Discocyrtus* sp. 1, however there is
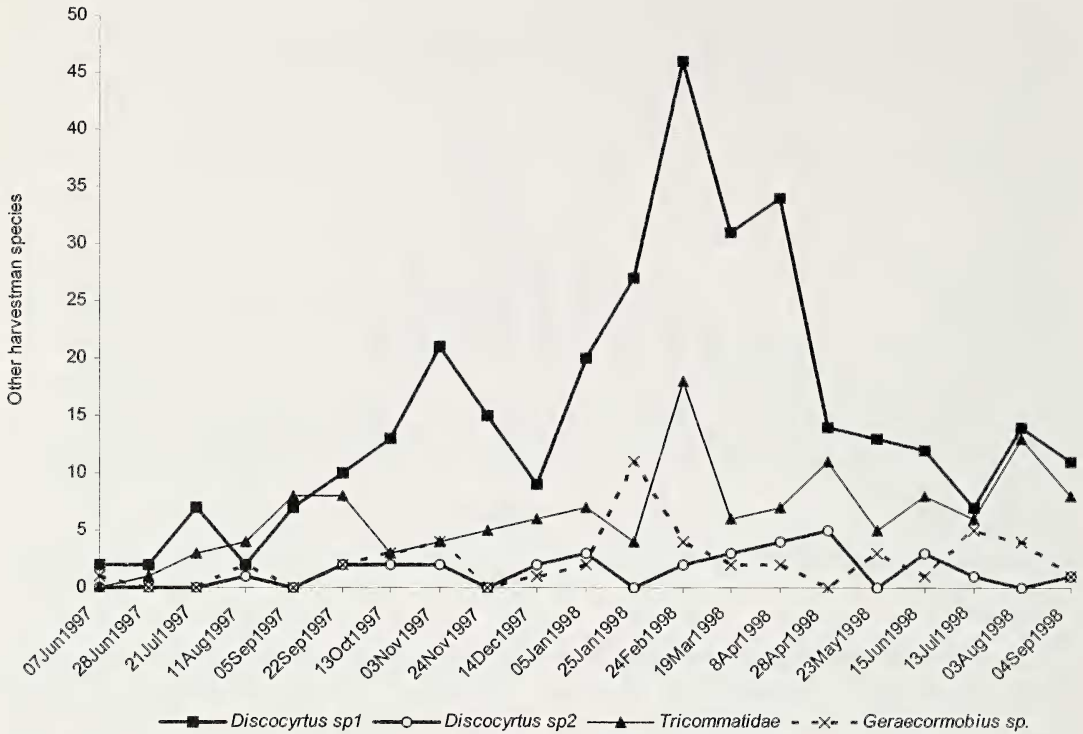
Figure 5.—Total number of four species of opilionids (adults and immatures) observed in an Araucaria forest fragment in Brazil.

insufficient data to strongly support this observation.

DISCUSSION

Biological activities of populations, mainly in tropical regions, can be linked to seasonal parameters such as temperature and rainfall (Opler et al. 1976; Winemiller 1989; Machado & Oliveira 1998). The harvestman *Cynortoides cubanus* Banks 1909 (Cosmetidae) decrease post-embryonic development at higher temperatures (Juberthie 1972). In the same way, there could be a specific temperature that favors *Ilhaia cuspidata* juveniles to survive in higher numbers until the adult stage. Our data show that the high number of juveniles observed in spring and summer was associated with the high number of adults observed in summer and autumn, suggesting that there is a definite period of successful reproduction, with a subsequent adult population increase.

The constant presence of juveniles during the whole year, suggests a continuous reproduction with a peak of emergence just after winter or, delayed hatching. Young and adults often are under different selection pressures,

and reproductive effort reflects the environmental factors that put pressure on the adults as well as on the juveniles (Pianka 1994). In this respect, a species with high mortality needs a corresponding high fecundity, persisting despite the great decline of the population (Pianka 1994). Very low temperatures should eliminate a great part of the population, mainly the juveniles. However, there could be a possible decrease in activity and/or movement to other shelters (under soil surface or fallen leaves, available all year) during the coldest times, resulting sub- or super-estimation in certain seasons.

In contrast to the cavernicolous harvestmen, such as *Goniosoma spelaeum* (studied by Gnaspini 1996), *Pachylospeleus strinatii* (studied by Pinto-da-Rocha 1996a), and *Daguerreia inermis* (studied by Pinto-da-Rocha 1996b), the epigean *I. cuspidata* had great seasonal variation in population size. In caves the temperature is less variable than epigean habitats (Culver 1982) and probably the seasonal temperature variation observed in the *Araucaria* forest influences this population. The al-

ternating sex ratio of the seasons could reflect these fluctuations.

The significant difference in harvestmen abundance in habitats with varying concentrations of trunks and bricks indicates that these shelter preferences can be linked to microhabitat conditions promoted by these materials. Wood and clay provide shelters with less temperature variation than stones and plastic objects. The great abundance of this harvestmen species in this study site could be linked to their adaptation or preference for these abundant shelters.

Capocasale & Bruno-Trezza (1964) observed that behavior of harvestmen was related to changes in the temperature. They demonstrated that the number of aggregated individuals of *Acanthopachylus aculeatus* (Kirby 1818) (Gonyleptidae) was inversely proportional to the temperature, with the largest aggregations occurring in lower temperatures. We observed that *I. cuspidata* increase in number of larger aggregations during the summer and autumn compared with the spring, thus the number of aggregated individuals was not increasing with lower temperatures. So, results suggest that the increase of aggregated individuals is not influenced by temperature, but probably by the population density. Aggregation occurs at the limited number of favorable shelter sites(with no light and high moisture, like bricks).

In contrast to *Goniossoma longipes* (Machado & Oliveira 1998) and *Goniosoma proximum* (Ramirez & Giaretta 1994), which guard their egg batches (60–210 eggs) or juveniles, parental care of the low number of egg batches (approximately 20 eggs) was not observed for *Ilhaia cuspidata*. We can not say if *I. cuspidata* only lays about 20 eggs during the entire reproductive period or lays several egg batches in different shelters as a way to avoid predation.

An increase in active individuals at dusk demonstrates that *I. cuspidata* is nocturnal, forages near shelters, and are restricted to small areas (around 50 m^2). This observation supports the concept of a small home range for gonyleptideans, as was also observed for *Goniosoma spelaeum*, *Daguerreia inermis* and *Pachylospeleus strinatii* (Gnaspini 1996; Pinto-da-Rocha 1996a, 1996b).

These harvestmen have a very broad diet, as was also observed for *Acanthopachylus*

aculeatus (Capocasale & Bruno-Trezza 1964), *Pachyloidellus goliath* (Acosta 1995), *Pachylospeleus strinatii* (Pinto-da-Rocha 1996) and *Goniosoma spelaeum* (Gnaspini 1996), *G. longipes* (Machado & Oliveira 1998), and *Daguerreia inermis* (Pinto-da-Rocha 1996b). Besides small live animals and plants, we observed this species feeding on the feces of birds and rats, an observation also documented by Hillyard & Sankey (1989) for another species, thus reaffirming an omnivorous diet for harvestmen.

The *I. cuspidata* population in this study experienced high fluctuations in the number of individuals, a probable delayed response to climate fluctuations. These population fluctuations were also observed for other harvestmen species in the study site, and possibly these harvestmen have similar responses to these environmental conditions.

ACKNOWLEDGMENTS

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Appendix 1.—Number of captured (CAP), released (REL) and recaptured (D1 = day, D2 = 22, second day of recapture, D3 = 45, third day of recaptures . . .) adults and subadults of *Ilhaia cuspidata* in Curitiba, Paraná, Brazil.

Day	CAP	REL	Recaptures								
			D1	D2	D3	D4	D5	D6	D7	D8	D9
1	292	292									
22	222	222	36								
45	272	272	23	35							
66	338	338	24	16	36						
91	297	295	17	9	26	30					
108	380	380	8	10	17	19	40				
129	298	290	6	7	12	15	30	33			
150	332	327	6	4	11	17	22	28	27		
171	339	339	7	7	13	13	18	26	15	40	
191	396	395	2	5	9	3	13	9	12	31	26
213	671	670	3	2	9	8	16	10	13	23	20
232	850	838	5	0	7	2	9	14	10	24	22
263	1314	1297	4	4	6	6	12	11	9	22	21
286	1526	1526	4	4	6	7	9	6	8	19	18
306	1896	1896	2	2	7	4	8	5	9	11	9
326	1738	1736	4	2	8	7	5	13	3	6	11
349	1304	1304	5	3	3	4	7	8	6	4	6
373	1105	1105	4	1	6	3	6	6	1	6	5
402	715	714	1	0	2	2	2	2	4	4	3
423	562	562	0	0	2	0	1	2	2	3	3
455	403	403	2	1	0	0	1	1	3	2	2

Appendix 1.—Extended.

					Recaptures					
D10	D11	D12	D13	D14	D15	D16	D17	D18	D19	D20
68										
35	143									
31	89	103								
22	42	68	150							
3	30	50	108	189						
7	21	24	57	114	227					
3	17	22	37	59	120	165				
4	7	8	32	41	83	92	102			
4	8	9	15	32	44	64	52	77		
2	2	4	10	27	27	37	30	50	50	
1	5	4	3	18	16	22	15	33	28	26